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Women in Science: Lessons from Australia

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ABSTRACT
Outstanding women are increasingly seen achieving at the highest levels and taking key roles in the fields of science and technology. However, a number of recent international studies provide evidence of persistent patterns of horizontal segregation (by discipline) and vertical segregation (by level of seniority and measures of esteem) of women in higher education and research. Research undertaken in Australia by the author Sharon Bell for the Federation of Australian Scientific and Technological Societies (FASTS) on women in science suggests that the question of women in higher education and research is a half-prosecuted agenda that continues to impact on productivity and innovation. This research affirms Professor Bell's earlier work on women in research undertaken for the Australian Vice Chancellors' Committee. It is argued that this agenda now needs to be advanced through systematic organisational cultural change and changes to our construction of the 'ideal science worker'. An evidence-based change implementation framework is proposed.

KEYWORDS
Gender; organisational change

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INTRODUCTION

As this paper goes to press Australia welcomes its first female Prime Minister, Julia Gillard. Simultaneously a colleague draws my attention to a paper from the June issue of the *Personality and Social Psychology Bulletin* 'The Price of Power: Power Seeking and Backlash Against Female Politicians'. This recent research (Okimoto and Brescoll, 2010) suggests that voting preferences for female candidates, but not male candidates, are negatively influenced by power-seeking intentions. A timely reminder that women face complex responses and require well-developed strategies to navigate organisational cultures if they are to crash 'glass ceilings'. Also a reminder that, to achieve enduring and inclusive change, organisational cultures themselves must change.

In October 2009, under the banner headline 'Women no longer the second sex?' University World News published a special report arguing that if you look to many universities around the world you'll see women outnumbering men. National evidence is supported by UNESCO's Global Education Digest 2009 which reports that in terms of graduation, 'women outnumber men in 75 of 98 countries with available data.' (University World News, 2009, Issue 0098).

For inspiration of a different order go to the Barbie® website: http://collectdolls.about.com/library/blbarbiefacts.htm Barbie® has, for non-aficionados, had 125 'careers' since 1959, from teenage fashion model to paleontologist. Her latest career is as a computer engineer, complete with PhD and pink laptop. Computer 'geeks' are already attempting to decipher the binary on her laptop, and debating whether her Bluetooth headphones are 'in character', http://gizmodo.com/5470587/computer-engineer-barbie-has-a-phd-in-fun-and-breaking-down-stereotypes
Interestingly this Barbie® career was decided 'for the first time ever' entirely from an on-line vote, http://www.barbie.com/vote/

Research conducted by the author for the recent FASTS Report *Women in Science in Australia: Maximising Productivity, Diversity and Innovation* (2009) certainly points to complex and persistent patterns of gendered distribution of students by discipline, of staff by discipline, by level and by institutional type, and by researchers against measures of excellence and esteem.

So if Barbie Millicent Roberts is to succeed as a computer engineer and aspire to achievement at the highest levels, the evidence is that she will need more than a good PhD. As one Gizmodo on-line commentator suggests ' I think the "Not All Dreams Can Come True" T-shirt would be perfect for this Barbie'. Barbie® in a 'non-traditional discipline' will need the strategies and support

to navigate a labyrinth of obstacles and challenges: mentors, sponsors and institutional cultures that foster flexibility, diversity and respect. (Bell, 2010, p. 10)

PERPETUATION OF THE GENDERED SCIENCE AND TECHNOLOGY ENVIRONMENT IN AUSTRALIA.

In 2008 the Federation of Australian Scientific and Technological Societies (FASTS) commissioned a report (Bell et al, 2009) in response to two long term issues around women's participation in science and technology: first, increasing concern in the Commonwealth government regarding levels of participation in science subjects in the senior years of high school and the follow on effects of this; and second growing awareness of the looming personnel shortages facing the academic and research sectors.

Having completed an earlier study on women in research for the Australian Vice Chancellors' Committee (Bell and Bentley, 2005) this represented an excellent opportunity to extend our knowledge of women's experience of the research environment in the 'research intensive' sciences. The timing of the study was also excellent. In 2006 the outcomes of the 2005 OECD workshop *Women in Scientific Careers: Unleashing the Potential* were available. The major aim of this workshop was to identify the causes behind the low participation of women in scientific careers, especially in certain fields and at senior levels, precisely the patterns of participation we had identified in Australia. Moreover, the US Academies had just produced their comprehensive report *Beyond Bias and Barriers* (2007) which reiterated the experiences documented by the OECD. We were keen to explore whether Australia continued to mirror these patterns, and to draw from the literature evidence of what has 'worked' for women and what has not. We were also very keen to explore the questions around under what circumstances women succeed at the highest levels.

Australia's science knowledge and skills base is fragile. Many research fields are increasingly dependent on international talent, and securing international talent is becoming extremely competitive. The FASTS Report *Women in Science in Australia* (2009) argues that identification of strategies to correct these trends through the participation and retention of women is crucial. The full report is available as a supplementary file (see link in 'Reading Tools': right-hand sidebar of the screen), but some of the major findings of this report are outlined below.

The patterns of representation of women in science and technology can be separated into two broad categories (Carrington and Pratt, 2003). First, horizontal segregation of women in the technology disciplines based on: perceptions regarding women's innate ability in science and mathematics; societal attitudes towards gender stereotypes and gender equality; and, job security and employability of graduates. Second, in science disciplines that are characterized by high female undergraduate and post-graduate participation, vertical segregation generated by: the organisational culture of

the workplace through practices that disadvantage women such as work load; promotions policies and practice; lack of female role models, mentors and networks; lack of accommodation of carer responsibilities; and, sex discrimination.

It is important to note that women's under-representation in senior academic positions does indicate barriers to 'success', but in Australia we cannot be sure that this equates to attrition. Women may be moving from the academy into productive work in industry, government or not-for-profit sectors commensurate with their knowledge and skills base. However, the absence of reliable data that tracks mobility of the scientific workforce between universities, industry and government means it is much harder to evaluate whether there is net attrition or simply a wide range of graduate and postgraduate outcomes. Available data from government agencies and industry does however suggest attrition, as the pattern of feminised lower ranks and male dominated senior ranks is replicated.

Achievement at the Highest Levels

In the FASTS report four measures of excellence and esteem were considered: Australian Research Council (ARC) Discovery and Linkage grants; the ARC Federation Fellow Scheme; admission to the learned academies of Science and Technological Sciences and Engineering; and, the newly introduced ARC Future Fellows scheme. Analysis of data on ARC grant schemes reveals some clear trends. All grant schemes have seen significant increases in applications over recent years. Success rates for male and female applicants are generally comparable. However, participation rates for women are lower than for males – in the case of the Discovery and Linkage grants, significantly so with men participating since 2002 at above 70% and women participating at below 30% (http://www.arc.gov.au).

In 2008, the ARC Future Fellowships scheme was introduced. The aim of ARC Future Fellowships is to attract and retain the best and brightest mid-career researchers. Results of the first Fellowship round show that women constituted 29% of applicants and secured roughly the same proportion of the Fellowships. The largest number of successful female applicants, however, was clustered in the lowest salary band (www.arc.gov.au/ncgp/futurefel/FT09_selection_rep.htm).Women made up only 8.5% of ARC Federation Fellows, the fellowships designed to attract world-class researchers and world-class research leaders to key positions (www.arc.gov.au/ncgp/fedfellows/ff_outcomes.htm).

Comparable trends are seen in the National Health and Medical Research Council Grants where trend data shows a decrease in female applicants as seniority in award increases but little evidence of discrimination at the level of assessment. In this national grant system there are also distinct patterns of participation and relative success in disciplinary groupings. For instance at the level of post-graduate scholarships in Biomedicine and Public Health applications from women far exceeded those by men, but success rates are

similar (48% and 54% for women and 46% and 55% for men). Yet for the prestigious Australia Fellowships only 14% of female applicants are successful compared with 21% and from 2002 – 2008 only 22 women applied for this prestigious fellowship compared with 138 men.

In the learned Academy of Science women constitute only 7% of Fellows. In this Academy there are 426 Fellows of whom 30 are women; just 1% more than five years ago. In the learned Academy of Technological Sciences and Engineering 6% of Fellows are female. There are 45 female Fellows from a Fellowship of 788, compared with 5% five years ago.

In this context it is encouraging to note that currently a number of key leadership roles in Australia are occupied by women: the Chief Scientist, the NSW Chief Scientist, the CEO of CSIRO and the CEO of the ARC, to name but a few. Nonetheless, without depth in female seniority in the sector this profile of leadership, arguably based on individual achievement, is fragile.

FASTS Recommendations

Following the approach of the US National Science Foundation (NSF), FASTS supports a multifaceted strategy to broaden participation in the science and technology workforce – in particular to realise the potential of women's participation. FASTS encourages the leaders of institutions of higher education and the broader science community (including government, professional societies, the learned academies, science and technology related industries and not-for-profit organisations) to address various aspects of science and technology organisational culture and institutional structure that may negatively affect women. Key recommendations include: identification of incentives for change including a stronger business case linking diversity with innovation; clear mapping of scientific career paths (including non-traditional career paths) with opportunities for leadership and mentorship identified in tandem with the systematic identification and elimination of barriers to women; following the EU example, ensuring that women constitute one third of policy-making, funding and decision-making boards; and, of course, the ever present need to improve the evidence base and consistent, systematic reporting of gender data in the sector on the part of the major research and research funding agencies.

A FRAMEWORK FOR CHANGE

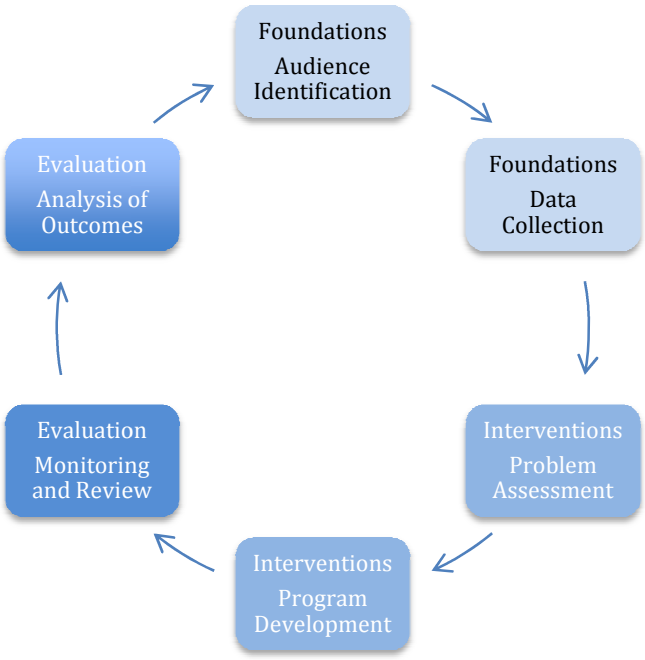
As indicated above, over the past decade a number of influential national and international reports have drawn attention to patterns of gendered participation and success, and concern has been voiced over the persistent patterns of gender inequity in the science and technology disciplines in particular, and the implications of this. The benchmark study internationally in this field was undoubtedly that conducted at Massachusetts Institute of Technology. In 1995, the MIT Dean of Science established a committee to analyze the status of women faculty in the School of Science. The committee discovered that:

> ...junior women faculty feel well supported within their departments and most do not believe that gender bias will impact their careers. Junior women faculty believe, however, that family-work conflicts may impact their careers differently from those of their male colleagues. In contrast to junior women, many tenured women faculty feel marginalized and excluded from a significant role in their departments. Marginalization increases as women progress through their careers at MIT. Examination of data revealed that marginalization was often accompanied by differences in salary, space, awards, re- sources, and response to outside offers between men and women faculty with women receiving less despite professional accomplishments equal to those of their male colleagues. **An important finding was that this pattern repeats itself in successive generations of women faculty. The Committee found that, as of 1994, the percent of women faculty in the School of Science (8%) had not changed significantly for at least 10 and probably 20 years.** (Emphasis added MIT, 1999, p.4)

It is fair to say that a great deal of research has described gendered patterns of participation in the sector whilst far less has addressed strategies for change. Perhaps not surprisingly, following the publication of the FASTS report, the most common response from senior leaders in the sector was 'just tell us what to do'. Again timing helped – as the FASTS report went to press Australian molecular biologist Professor Elizabeth Blackburn was confirmed as the first Australian woman Nobel laureate. This honour led to a raft of speaking and media engagements that highlighted not only the importance of Professor Blackburn's research, but also her experience as a female scientist and the question of 'tell us what to do' became more pressing.

Drawing on the MIT experience and numerous more recent studies the following framework outlines an approach to organisational change that is built on the available evidence base. It is premised on the need to move beyond compliance with the equal opportunity legislative environment (taken as a given in higher education and government) to focus on equality of outcomes. This inevitably demands systematic organisational cultural change, ensuring that 'women have no doors closed to them that are open to men' (Cockburn, 1991, p.31). This is a move from 'accommodation' of women to 'reframing' the professional environment – a move that also calls into question conventional masculinities. (Williams, 2000, p.271)

The framework utilizes the Advocacy and Policy Change Composite Logic Model developed by The Aspen Institute (http://www.planning.continuousprogress.org).



Equity implementation Cycle

The impact that is sought is an improved professional environment for women and men that supports and rewards a diversity of individuals and groups and ends the sexual division of labour (Cockburn, 1991; Williams, 2000). The aim is to: acknowledge and identify tacit values and assumptions that underpin established linear career norms ('the ideal higher education worker'); interrogate how these are reflected in policies and practices; and, make explicit the value of supporting a broader range of 'ideal higher education workers', many of whom will have non-linear and/or interrupted career paths and a wider diversity of career destinations. The benefits of achieving greater diversity are well documented in terms of equity, productivity and innovation (Cutler & Co, 2008; Gratton et al, 2007). The greater challenge is to ensure that increased diversity is linked to excellence based on demonstrable improvement at all levels and in all disciplines enabling a greater range of higher education workers to attain success at the highest levels.

LAYING THE FOUNDATIONS

The Audiences

Within the higher education environment there is an increasingly broad range of target audiences who influence the organisational culture. Identification of the key audiences is an important first step to acknowledge as communication strategies are developed. If initiatives are not framed in ways that connect with a diversity of critical audiences and generate wide ownership, change, particularly of entrenched academic and professional norms and values, will be difficult to achieve. Audiences are likely to include:

- Staff, academic and professional, and target groups within these eg female early career researchers, senior male leaders;

- Senior women as role models, mentors and change agents;
- Gatekeepers including professional associations;
- Funding agencies;
- Business and community leaders; and,
- Students (some of whom are also staff) who represent the next generation of higher education workers.

The initial focus should obviously be on the first two groups. There are some arguments for the early steps to be taken in a manner that instills confidence prior to external engagement (Bailyn, 2003).

Data Collection

Each organisational profile is different and demands customized data collection and responses. However, there are a number of well-documented patterns that point clearly to what we need to know. There are also a number of well-entrenched assumptions that may have been historically accurate, but that probably no longer hold true, especially since we began taking learning and teaching and 'engagement' or 'knowledge transfer' more seriously in our appointment and promotions processes. A very good example is the well-documented perception that women are not selected or promoted as readily as men (Winchester et. al., 2006). The evidence is that in higher education in Australia this pattern is changing (this does not mean there are not entrenched pockets of resistance or differences between disciplinary fields). However, women are more likely than their male colleagues to:

- have 'non-traditional' career paths (Stevens-Kalceff et. al., 2007; Diezmann & Grieshaber, 2009);
- start their careers at lower levels (and many later) than men as research assistants (Hobson et al, 2005) or at Level A (Probert et. al., 1998);
- begin their careers without a PhD and are less likely to go on to complete one (Probert, 2005) although this is changing rapidly (Edwards et al, 2009);
- publish less whilst undertaking a PhD (Dever, 2008);
- publish less quantity but higher quality (Symonds et al, 2006);
- pursue their careers less aggressively (Probert, 2005) motivated by intrinsic rather than extrinsic factors (Dever, 2008);
- have higher undergraduate teaching loads and lower post-graduate teaching loads (Probert, 2005);
- apply for promotion less frequently than men (Probert, 2005; Winchester et al, 2006);
- spend more time on student welfare and pastoral care (including mentoring) (Probert, 2005);
- have greater difficulty finding time for research when they are juggling carer responsibilities throughout their careers (caring for infants, teenagers, spouses and ageing parents) (Probert, 2005) and perform the

majority of household duties (Schiebinger and Gilmartin, 2010, Diezmann & Grieshaber, 2009);
- are, compared to men, differentially and negatively impacted by the 'culture of long hours' characteristic of the academic environment (Coates et al, 2009; Cockburn, 1991), and;
- fail to participate at levels comparable to men in the national competitive grant and fellowship processes (in both research and learning and teaching) that are critical to success and esteem (Bell & Bentley, 2005; Bell et. al., 2009).

In short, many women do not fit the established expectations of the 'ideal higher education worker'.

Whilst Diezmann and Grieshaber (2009) find that there was no statistical difference between the number of female and male appointees to the professoriate (2005-2008) they did find that women are appointed two years later than males and significant proportions of women, according to Probert stop climbing prior to this 'as soon as they are getting to their peaks'. We need to understand more about this, but research suggests several factors that may be important: men are more likely to have supportive partners who are not in full-time employment (Probert, 2005); the cumulative experience of negative discrimination coupled with the continuing influence of "the boys' club" (Diezmann and Grieshaber, 2009); another is age profile and stage of career, which we do not know enough about.

This paints a picture of small cumulative disadvantages consistent with the international research (see National Academies, 2007 and Eagly and Carli, 2007). We also know that mentoring and sponsorship have a significant positive impact (Russo, 2010; Blau et al, 2010; Diezmann and Grieshaber, 2009; Dever et al, 2006).

This reinforces the imperative for any proposed program to be under-pinned by diagnostic data to develop an organisational specific evidence base. This will assist in targeting appropriate initiatives and addressing emerging policy and practice issues, and will also provide a basis for monitoring and evaluation. The relevant data would include:

1. Patterns of attraction and recruitment: breakdown of applicants for positions advertised by role and gender (over past 5 years);
2. Selection outcomes: shortlisted applicants by role and gender; successful applicants by role and gender. Following Ehrenberg et al (2009) it would also be useful to have a report on the composition of selection committees by gender, including gender of Chair;
3. The current staff profile by: unit, position type and level, employment status (full-time; fractional), length of service, highest qualification, age and gender;

4. Remuneration (including gender pay gaps) and access to resources and professional opportunities (such as overseas travel);
5. Data on retention (by level, unit, etc) to identify who is staying and who is leaving (together with destinations if known);
6. Promotion data by level and discipline/role;
7. Data on carer/family responsibilities;
8. Internal research and learning and teaching grant participation and outcomes by gender;
9. Where relevant, external income by gender (given this forms the basis of performance assessment and ongoing employment in a research based institution for some staff); and,
10. Workload data where available, including the patterns of distribution of administrative workloads, inclusion/exclusion of pastoral care/mentoring and 'gendered' roles such as those that focus on student support eg First Year Advisors/Co-ordinators, Program Convenors etc;

Items 3 & 4 are the essential baseline data. If trend data is available this is an invaluable resource.

INTERVENTIONS

Problem Assessment

The above data will provide quantitative indicators that will help identify patterns of gendered employment, potential target groups and variation across organisational units. To gain a greater understanding of organisational dynamics it may be useful to use one of the available survey tools or interrogative frameworks (Meyerson & Fletcher, 2000). It might also be useful to conduct a small number of focus groups to map aspects of perceived organisational culture. The Organisational Maturity Framework (Crosby, 1980; Bell and Cameron, 2005; PWC/HEFCE, 2005) is a benign tool that provides very useful enabling data that can be used to facilitate strategic conversations. The maturity framework suggests a logical progression to demonstrate the progress being made towards the goals set, in this case to improve gender equity. Indicators associated with each stage identify where the organisation is in terms of the maturity framework. The framework helps make clear what works within the organisational culture and how this might be experienced differently by people in different roles and in different organisational units. It also enables the collection of qualitative data (Neale & Bell, 2010).

PROGRAM DEVELOPMENT

A successful program will be developed with several broad aims in mind (Bell et. al., 2009):

- to reinforce the need for continuity where there has been success;

- to focus strongly on the role of (male and female) leaders in taking responsibility for creating and maintaining positive organisational cultures, in part to ensure that change is holistic rather than piecemeal and 'to get the equality initiative placed in a high and secure position' (Cockburn, 1991, p.31);
- to identify and remove barriers to women's career progression and success;
- to sustain change, address and monitor the participation of women in relevant policymaking and decision making processes; and,
- to improve the evidence base, share best practice and ensure that interventions are appropriately framed and evaluated.

Although each organisational culture is different, and demands close analysis, the research indicates that there are a number of critical dimensions to achieving the organisational change outlined above:

1. 'Top-level' commitment from senior managers and leaders, who take responsibility for linking the gender agenda to organisational goals and sustainability (PWC/HEFCE, 2004; Bailyn, 2003) together with identification and support of high profile male and female organisational champions (Bell et. al., 2009; Browning, 2009; Prime and Moss-Racusin, 2009).
2. The mapping of career paths to identify catalysts and inhibitors (Eagly and Carli, 2007; Stephens-Kalceff, 2007; Deizmann & Grieshaber, 2009; Dever, 2008)
3. The provision of support through mentoring (Devos, 2005; Diezmann & Grieshaber, 2009; Blau et al, 2010; Russo, 2010). See also LH Martin Universities Australia Executive Women website http://www.mihelm.unimelb.edu.au/mentoring/uaew/index.html
4. Critical policy and process analysis (selection, performance, promotion, reward & recognition, and working conditions including leave provisions and flexibility) to identify and address 'inhibitors' (Winchester, 2005; Dever et. al., 2006) including the impact of panel/decision-making committee composition (Ehrenberg et. al., 2009) and impact of performance timeframes.
5. Support for sustained structured networks, task-forces or committees that include men (Bailyn, 2003; Cockburn, 1991)

There is also evidence that interventions need to be multi-faceted. Eileen Byrne (1994) argues that 'the linear (and single dimensional) approach to intervention policies which characterised the 1980s and early 1990s, including the over use of short term projects, is ineffective, and should be replaced by a cluster approach, in which groups of factors, influences or

issues need to be tackled simultaneously by policies which are related and planned as interacting' (p.2).

REVIEW AND EVALUATION

One of the key limiting factors in the research is the paucity of evaluation. As Byrne (1994) points out many interventions have been in the form of short-term projects, and even those that appear to be successful are not evaluated. Wherever possible interventions should be structured so that relevant input and outcome data can be generated and analysed as a basis for continuous improvement. The different findings of the whole of institution (Probert, 2005) and discipline based (Stephens-Kalceff, 2007) studies of the University of NSW are instructive and point to the need for institutional monitoring of performance against indicators coupled with continuous validation through small scale studies.

CONCLUSION

This paper argues for the acknowledgement of persistent patterns of gendered participation and success in science and technology and cautions against the premature abandonment of a half-prosecuted gender agenda. It also argues that the means to achieve this is through systematic organisational cultural change – a need that has been recognized for two decades (Cockburn, 1991; Sinclair, 1994).

The examples of extraordinary individual achievement of women in the academy, in research and in some disciplines at the undergraduate and postgraduate levels is cause for cautious optimism. But many of these women have arguably achieved success despite the system rather than through profound changes in our expectations of the 'ideal worker' and attendant organisational and professional cultures. It is argued that such organisational change is the next step. The evidence is that such change can be achieved, albeit incrementally, if premised on systematic approaches informed by close analysis, adaptation and replication of successful strategies and interventions, and monitoring and evaluation of outcomes.

The timeliness of the FASTS Report, together with renewed interest in research workforce and succession planning, has provided further cause for optimism. It should be noted however that to reinvigorate the 'stalled revolution' women will need more than the 'person centered' or 'deficit' approach that gives women 'stilts to walk on an uneven playing field' (Piterman, 2008, p.12). Stilts can be helpful, and even necessary, but real, sustained change will be led by those men and women who understand the benefits of diversity in the research workforce and who are willing to countenance change in often highly regarded 'historic practices'.

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